Nesting Populations of Double-Crested Cormorants in the United States and Canada

By Laura A. Tyson, Jerrold L. Belant, Francesca J. Cuthbert, and D. V. (Chip) Weseloh

Abstract: Double-crested cormorants *(Phalacrocorax auritus)* are receiving increasing attention in North America because of depredations at aquaculture facilities and alleged impacts on sport and commercial fisheries. We obtained recent (most since 1994) estimates for the number of nesting double-crested cormorants in the United States and Canada from published references and by conducting telephone interviews with State and Provincial biologists. Using published data, we also determined annual rates of change in the number of cormorants since about 1990. The estimated minimum number of nesting pairs (colonies) of double-crested cormorants was 372,000 (852). Most cormorants nested in the Interior region (68 percent). Overall, double-crested cormorants increased about 2.6 pecent annually during the early 1990's. The greatest decline (–7.9-percent annual change) was in the West Coast–Alaska region. The greatest increase (6.0-percent annual change) was for the Interior region. The increase there was primarily a consequence of a 22-percent annual increase in Ontario and U.S. States bordering the Great Lakes. These baseline population data are essential for monitoring trends in nesting populations and for developing informed management decisions. However, the completeness, quality, and timing of surveys varied substantially among jurisdictions. Population estimates and rates of change should, therefore, be used with caution. Methods and timing of future surveys should be coordinated among political jurisdictions (at least within regions) to improve accuracy of estimates and allow more meaningful comparisons of population status.

Keywords: aquaculture, Canada, double-crested cormorant, nesting, *Phalacrocorax auritus,* piscivorous birds, population, United States

The double-crested cormorant (DCCO) has an extensive range in North America, occurring throughout the interior as well as on both coasts. Mendall (1936) reported that in New England cormorants were eliminated as nesters by the late 19th century. Resident populations in the South-Central United States disappeared, and wintering populations declined through the middle of the 20th century (Jackson and Jackson 1995). In the 1800's and early 1900's, numbers of cormorants declined along the Pacific coast (Carter et al. 1995). From 1950 to 1970, the Interior and California populations declined while the Atlantic population merely stopped growing (Hatch 1995). However, by the 1980's, most populations were increasing (Jackson and Jackson 1995, Carter et al. 1995, Krohn et al. 1995).

Weseloh et al. (1995) found literature reporting the first suspected nesting on the Great Lakes between 1913 and 1920. By 1950, the breeding population was about 900 pairs (Weseloh et al. 1995). Human persecution and environmental contaminants led to virtual extinction of cormorants from the Great Lakes by the early 1970's (Weseloh et al. 1995, Blokpoel and Tessier 1996). Reduction in contaminant levels and persecution and an abundance of prey fish have been major factors leading to a dramatic increase in the Great Lakes population from 89 nests in 1970 to more than 38,000 nests in 1991 (Weseloh et al. 1995, Blokpoel and Tessier 1996). By 1997, the Great Lakes population had reached about 93,000 pairs.

These increased populations of cormorants in North America are causing conflicts with aquacultural interests as well as commercial and sport fisheries (Bédard et al. 1995, Duffy 1995, Krohn et al. 1995, Milton 1995). In the Southeastern United States, Belant et al. (in press) determined that fewer than 8,000 cormorants were killed annually to protect aquaculture facilities from 1987 through 1995. Concerns have been expressed regarding the effects of lethal control at aquaculture facilities on local, regional, and national populations of piscivorous birds (Trapp et al. 1995). However, no study has addressed this fundamental issue. To assess the impacts of lethal control, current estimates of population size and rates of change are essential. Our objectives were to (1) obtain the most recent population estimates for nesting DCCO's in North America, (2) determine the rate of change in their populations, by region, during the early 1990's, and (3) determine the techniques used for censusing populations and suggest means for obtaining better continuity in survey methods.

Methods

To obtain the most recent population estimates for cormorants in jurisdictions excluding the Great Lakes, we conducted telephone interviews from May through October 1996 with biologists from each State (excluding Hawaii), Province, and Territory in the United States and Canada when publications or reports were unavailable (see Belant and Tyson, in press). Information requested included the number of nests and colonies and the survey technique used to obtain estimates. For Ontario and States bordering the Great Lakes, field counts were conducted in 1997. As described by Hatch (1995), each estimate provided was placed in one of four categories of decreasing precision, ranging from a recent complete count (category A) to a conjecture based on old or incomplete information (category D). In addition, complete data in several States and Provinces were lacking. Population estimates were grouped into one of four regions: Interior, Atlantic, Southeast, and West Coast-Alaska (fig. 1) (modified from Hatch 1995).

To estimate population changes during the early 1990's, we compared these most recent estimates with those previously obtained by Hatch (1995). We determined the mean percent annual change (MPAC) in the number of nesting cormorant pairs using the formula

$$MPAC = [(N_2 / N_1)^{1/y} - 1] * 100$$

where N_1 is the number of nests from the first estimate (from Hatch 1995) and N_2 is the number of nests from the second estimate, *y* years later.

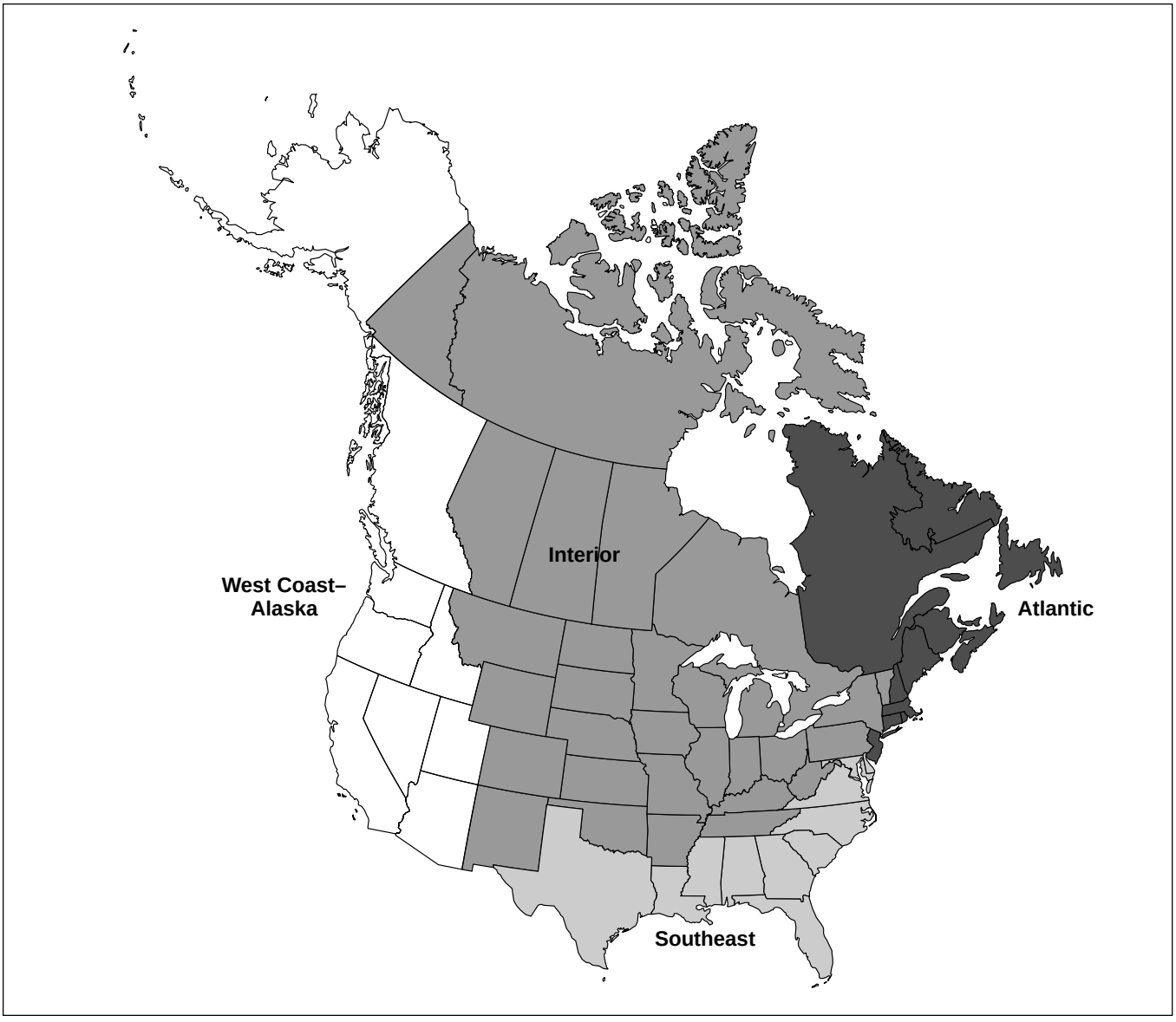

Figure 1—Geographic boundaries for regional populations of double-crested cormorants in the United States and Canada (modified from Hatch 1995).

Results

Of the 63 State or Provincial estimates, 44 (70 percent) were made in 1994 through 1997. The remainder ranged from 1975 through 1993. On the basis of estimates from all States and Provinces, the number of nesting DCCO's in the United States and Canada increased about 2.6 percent annually from about 1990 through 1994 (approximately 336,490 to 372,410 nesting pairs) (table 1). If data only from States and Provinces with category A estimates are used, the MPAC was 16.2 percent. Most birds were found in the Interior region (68 percent, 256,212 pairs), followed by the Atlantic (23 percent, 85,510 pairs), West Coast–Alaska (5 percent, 17,084 pairs), and Southeast (4 percent, 13,604 pairs) regions.

Although the overall MPAC was 2.6 percent, population changes varied considerably among regions. The greatest regional decline (–7.9-percent annual change) occurred in the West Coast–Alaska region. The greatest regional increase (6.0-percent annual change) occurred in the Interior. The increase in the Interior was primarily a consequence of a 22-percent annual increase in the number of nesting pairs in Ontario and the States bordering the Great Lakes: cormorants in these jurisdictions increased from about 41,540 pairs in 1992 to about 93,026 pairs in 1997 (appendix 1). There were 852 or more DCCO nesting colonies (≥313 in the Atlantic, ≥281 in the Interior, ≥243 in the West Coast and Alaska, and ≥15 in the Southeast regions).

Table 1. Regional estimates of nesting pairs and mean percent annual change (MPAC) in populations of double-crested cormorants in the United States and Canada (about 1990–94)

Region	Approximate years of two most recent surveys for all States and Provinces		Estimated no. nesting pairs for all States and Provinces (no. colonies) (Year 2)	MPAC[1]	
	Year 1[2]	Year 2		All States and Provinces	States and Provinces with category A estimate
Atlantic	1991	1993	≥85,510 (≥313)	–6.5(13)	15.8(3)
Interior	1991	1995	≥256,212 (≥281)	6.0(30)	20.8(5)
Southeast	1991	1994	>13,604 (>15)	2.6(11)	76.9(2)
West Coast–Alaska	1989	1993	≥17,084 (≥243)	–7.9(9)	–0.6(1)
Total	~1990	~1994	≥372,410 (≥852)	2.6(63)	16.2(11)

[1] Values in parentheses refer to number of States and Provinces included in estimate of MPAC. See footnote 1 in appendix 1 for definition of category A population estimates.

[2] From Hatch (1995).

Discussion

The number of DCCO's generally increased rapidly from the 1970's to the early 1990's (Hatch 1995). For example, the number of cormorant nests in the Great Lakes increased from 89 in 1970 to 38,000 in 1991, an annual increase of 29 percent (Weseloh et al. 1995). The number of cormorants in the Northeastern United States (within the Atlantic population) increased from 17,100 nesting pairs in 1977 to 34,200 in the mid-1980's and then increased slightly to 37,600 pairs in the early 1990's (Krohn et al. 1995). Our most recent estimates of cormorant numbers suggest that the overall rate of growth in the United States and Canada slowed substantially during the early 1990's. In agreement with our findings, the overall MPAC (8.0 percent) for cormorants in the United States and Canada for 1992 through 1996, based on survey data from the North American Breeding Bird Survey (BBS), was not different *(P* = 0.25) from zero (Sauer et al. 1997).

Although the number of nesting pairs of DCCO's in the United States and Canada increased only slightly during the early 1990's, regional populations varied more dramatically. We are uncertain of the causes for recent declines in the Atlantic and West Coast–Alaska nesting populations. In the Atlantic population, reduced suitability of colony sites may have led to recent population declines (Krohn et al. 1995). In addition, a management program of egg oiling and shooting adult nesting cormorants in the St. Lawrence estuary, which began in 1989, may have contributed to the decline (Bédard et al. 1995). Local declines in the number of cormorants in the West Coast and Alaska may be due to habitat loss, pollution, human disturbance, and introduced predators (Carter et al. 1995).

Data from the BBS for DCCO's in the Mississippi flyway for 1992 through 1996 (MPAC 22.0 percent, *P* = 0.04 [Sauer et al. 1997]) also supported our findings that populations in the Interior region were still increasing. This continued increase in the Interior population was a consequence primarily of dramatic population increases in the Great Lakes area. The number of cormorants in this area increased from about 38,000 pairs in 1991 (Weseloh et al. 1995) to roughly 93,000 pairs estimated in our 1997 study. Weseloh's team attributed continued increases in the Great Lakes to reductions in contaminant levels, low human persecution, high reproductive success, and increased availability of prey (e.g., alewife *[Alosa pseudoharengus]).* Exploitation of catfish *(Ictalurus* sp.) as a winter food in the Southeastern United States, especially at aquaculture facilities in the Mississippi delta, may also have enhanced survival of migrating cormorants (Williams 1992). The majority of cormorants nesting in the Great Lakes winter in Southeastern United States, concentrating in the lower Mississippi Valley (Dolbeer 1991).

The reported population estimates do not include subadult birds and nonbreeding adult birds; thus, total numbers of cormorants are greater. For example, 0.6–4.0 nonbreeding cormorants per breeding pair have been estimated for several populations (McLeod and Bondar 1953, Price and Weseloh 1986, Watson et al. 1991). Therefore, we conservatively estimate the total number of DCCO's in the United States and Canada at greater than 1 million individuals.

This report provides updated nesting population estimates for DCCO's in the United State and Canada. These baseline data are essential for monitoring future trends in nesting populations and for developing informed management decisions. However, the initial population estimates and rates of population change presented in this report should be used with caution. As in a similar study of laughing gulls *(Larus artricilla)* (see Belant and Dolbeer 1993), disparity among jurisdictions in survey techniques, intensity of searches, observer bias, and timing of surveys precluded statistical analyses of data. As shown in our analysis, the estimate of MPAC for cormorants varies, depending on the use of all counts (categories A–D) *v.* the use of only complete counts (category A).

Surveys from boats, aircraft, vantage points on land, and aerial photographs (Carter et al. 1995, Weseloh et al. 1995) in which nests are systematically counted should result in the most accurate estimates (i.e., category A). Superficial surveys, incomplete counts, or conjectures based on old information (i.e., categories B–D) result in unreliable estimates that should be used with caution. We recommend coordination of surveys using objective methodologies

among political jurisdictions (at least within regions) to allow direct comparisons of population status and to reduce biases (see Erwin et al. 1984).

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References Cited

Andrews, R.; Ryder, R. 1992. Colorado birds. Denver, CO: Denver Museum of Natural History.

Bédard, J.; Nadeau, A.; Lepage, M. 1995. Double-crested cormorant culling in the St. Lawrence estuary. Colonial Waterbirds 18 (Spec. Publ. 1): 78–85.

Belant, J. L.; Dolbeer, R. A. 1993. Population status of nesting laughing gulls in the United States, 1977–1991. American Birds 47: 220–224.

Belant, J. L.; Tyson, L. A. In press. Nesting populations of double-crested cormorants, great blue herons and great egrets in the United States and Canada: implications for management. Proceedings of the Eastern Wildlife Damage Control Conference 8.

Belant, J. L.; Tyson, L. A.; Mastrangelo, P. M. In press. Effects of lethal control at aquaculture facilities on populations of piscivorous birds. Wildlife Society Bulletin.

Blokpoel, H.; and Tessier, G. D. 1996. Atlas of colonial waterbirds nesting on the Canadian Great Lakes, 1989–91. Part 3. Cormorants, gulls and island-nesting terns on the lower Great Lakes system in 1989. Tech. Rep. Ser. No. 225. [Place of publication unknown]: Canadian Wildlife Service, Ontario Region. 74 p.

Cairns, D. K., Montevecchi, W. A.; Threlfall, W. 1989. Researcher's guide to Newfoundland seabird colonies. Second ed. Occas. Pap. Biol. 14. St. Johns, NF: University of Newfoundland.

Campbell, R. W.; Dawe, N. K.; McTaggart–Cowan, I.; Cooper, J. M.; Kaiser, G. W.; McNall, M.C.E. 1990. The birds of British Columbia, vol. 1. Victoria, BC: Royal British Columbia Museum. 243 p.

Carter, H. R.; Sowls, A. L.; Rodway, M. S.; Wilson, U. W.; Lowe, R. W.; McChesney, G. J.; Gress, F.; Anderson, D. W. 1995. Population size, trends, and conservation problems of the double-crested cormorant on the Pacific Coast of North America. Colonial Waterbirds 18 (Spec. Publ. 1): 189–207.

Dolbeer, R. A. 1991. Migration patterns of double-crested cormorants east of the Rocky Mountains. Journal of Field Ornithology 62: 83–93.

Duffy, D. C. 1995. Why is the double-crested cormorant a problem? Insights from cormorant ecology and human sociology. Colonial Waterbirds 18 (Spec. Publ. 1): 25–32.

Erskine, A. J. 1992. Atlas of breeding birds of the Maritime Provinces. Halifax, NS: Nova Scotia Museum.

Erwin, M. R.; Geissler, P. H.; Shaffer, M. L.; McCrimmon, D. A. 1984. Colonial waterbird monitoring: a strategy for regional and national evaluation. In: McComb, W., ed. Proceedings—workshop on management of nongame species and ecological communities; [date and place of meeting unknown]. Lexington, KY: University of Lexington: 342–357.

Hatch, J. J. 1995. Changing populations of double-crested cormorants. Colonial Waterbirds 18 (Spec. Publ. 1): 8–24.

Herron, G. B., ed. 1994. Population surveys, species distribution, and key habitats of selected nongame species. Job Perf. Rep. Proj. W–53–R–20; Study I, Jobs 1–6. Reno, NV: Nevada Division of Wildlife. 30 p.

Jackson, J. A.; Jackson, B.J.S. 1995. The double-crested cormorant in the South-Central United States: habitat and population changes of a feathered pariah. Colonial Waterbirds 18 (Spec. Publ. 1): 118–130.

Krohn, W. B.; Allen, R. B.; Moring, J. R.; Hutchinson, A. E. 1995. Double-crested cormorants in New England: population and management histories. Colonial Waterbirds 18 (Spec. Publ. 1): 8–24.

McLeod, J. A.; Bondar, G. F. 1953. A brief study of the double- crested cormorant on Lake Winnipegosis. Canadian Field Naturalist 67: 1–11.

Mendall, H. L. 1936. The home-life and economic status of the double-crested cormorant *Phalacrocorax auritus auritus* (Lesson). Maine Bulletin 39: 23–38.

Milton, G. R.; Austin–Smith, P. J.; Farmer, G. J. 1995. Shouting at shags: a case study of cormorant management in Nova Scotia. Colonial Waterbirds 18 (Spec. Publ. 1): 91–98.

Palmer–Ball, B.; Wethington, T. 1994. 1994 Survey of Kentucky heronries. Kentucky Warbler 70: 77–83.

Peterson, R. A. 1995. South Dakota breeding bird atlas. Aberdeen, SD: South Dakota Ornithological Union. 53 p.

Price, I. M.; Weseloh, D. V. 1986. Increased numbers and productivity of double-crested cormorants, *Phalacrocorax auritus,* on Lake Ontario. Canadian Field-Naturalist 100: 474–482.

Sauer, J. R.; Hines, J. E.; Gough, G.; Thomas, I.; Peterjohn, B. G. 1997. The North American Breeding Bird Survey results and analysis, version 96.3. Laurel, MD: Patuxent Wildlife Research Center.

South Carolina Department of Natural Resources. 1996. South Carolina waterbird database. Green Pond, SC: South Carolina Department of Natural Resources. [Unpaginated.]

Trapp, J. L.; Doggett, T. J.; Nickum, T. G. 1995. Management responsibilities and policies for cormorants: United States Fish and Wildlife Service. Colonial Waterbirds 18 (Spec. Publ. 1): 226–230.

Trost, C. H.; Gerstell, A. 1994. Status and distribution of colonial nesting waterbirds in southern Idaho, 1993. Tech. Bull. 94–6. Pocatello, ID: Idaho Bureau of Land Management.

Watson, G. E.; Olson, S. L. Olson; Miller, J. R. 1991. A new subspecies of the double-crested cormorant, *Phalacrocorax auritus,* from San Salvador, Bahama Islands. Proceedings of the Biological Scoiety of Washington 104: 356–369.

Weseloh, D. V.; Ewins, P. J.; Struger, J.; Mineau, P.; Bishop, C. A.; Postupalsky, S.; Ludwig, J. P. 1995. Double-crested cormorants of the Great Lakes: changes in population size, breeding distribution and reproductive output between 1913 and 1991. Colonial Waterbirds 18 (Spec. Publ. 1): 48–59.

Williams, T. 1992. Killer fish farms. Audubon 94(2): 14–22.

Reference Cited—Unpublished

Carter, H. R.; McChesney, G. J.; Takakawa, J. E.; Ochikubo, L. K.; Whitworth, D. L.; Keeney, T. W.; McIver, W. R.; Strong, C. S. 1996. Population monitoring of seabirds in California: 1993–1995 aerial photographic survey of breeding colonies of common murres, Brandt's cormorants, and double-crested cormorants. Final rep. Dixon, CA: U.S. Geological Survey, Biological Resources Division, California Science Center. 213 p.

Appendix 1—State and Provincial estimates of nesting pairs and mean percent annual change (MPAC) in populations of double-crested cormorants in the United States and Canada (about 1990–94)

Region	Years of two most recent surveys	Estimated number of nesting pairs (no. colonies)[1]		MPAC	Source[3]
	Year 1[2]/Year 2	Year 1[2]	Year 2		
Atlantic					
Connecticut	1992/1995	623A	716(11)A	4.7	1 UD
Maine	1992/1994	28,004B	≥20,692(117)C	–14.0	2 UD
Massachusetts	1992/1994–95	7,000B	7,274(28)A	1.9 to 1.3	2 UD
New Brunswick	1990/1990	7,800B	7,800B		3
New Hampshire	1992/1995	325B	≥483(1)B	14.1	4 UD
New Jersey	1992/1992	109A	109(≥1)A		5
New York– Atlantic	1992/1995	2,513A	≥3,528(8)A	12.0	6 UD
Newfoundland	1975–89/1975–89	261C	261C		5
Nova Scotia	1992/1993	15,200B	13,500(67)C	–11.2	7 UD
Prince Edward Island	1990/1995	7,000B	6,619(6)C	–1.1	8 UD
Quebec	1992/1993–96	27,000B	22,400(68)A	–17.9 to –4.8	9 PC
Rhode Island	1992/1994	1,700A	2,082(5)C	10.7	2 UD
St. Pierre et Miq.	1987/1989	40B	46(1)B	7.2	10
Subtotal	~1991/~1993	97,575	≥ 85,510(≥313)	–6.4	
Interior					
Alberta	1992/1996	7,000C	~7,000(~22)C	0	11 PC
Arkansas	1991/1991	15A	15A		5
Colorado	1990/1990	1,000C	1,000(~13)C		5, 12
Illinois	1992/1995	355C	675(6)C	23.9	13 UD
Indiana	1992/1996	0	0	14 PC	
Iowa	1992/1995	400C	689(4)C	19.9	15 UD
Kansas	1985/1996	20C	100D	15.8	16 PC
Kentucky	1991/1994	0	0		17
Manitoba	1992/1992	125,000C	125,000C		5
Michigan	1988–90/1997	7,975B	30,061(33)A	18.0	18
Minnesota	1990/1991–95	7,970C	≥6,439(≥37)C	–19.2 to –4.2	19 UD
Missouri	1992/1995	0	0		20 PC
Montana	1992/1988–95	850C	~1,475(~17)B		21 UD
Nebraska	1992/1992	850C	850C		5
New Mexico	1992/1996	730B	730(5)C	0	22 UD
New York–Interior	1992/1997	5,890A	9,129(12)A	9.2	18
North Dakota	1992/1992	1,200D	>1,200D		23 PC
Northwest Territories	1996		?[4]		24 PC
Ohio	1992/1997	180A	1,380(1)A	50.3	18
Oklahoma	1992/1995	0	[5]46(1)		25 PC
Ontario	1992/1997	16,170A,C	35,905(77)A	17.3	26
Pennsylvania	1991/1996	0	0		27 PC
Saskatchewan	1991/1991	19,547C	19,547C		5
South Dakota	1992/1991	850C	[6]>2,962(≥11)C		28
Tennessee	1991/1996	10C	11(1)A	1.9	29 PC
Vermont	1992/1995	555A	2,211(5)A	58.5	30 PC
West Virginia	1990/1996	0	0		31 PC
Wisconsin	1992/1997	3,000C	9,437(11)A	25.8	18
Wyoming	1986/1994	3,000B	≥350(25)D	–23.6	32 UD
Yukon Territory	1996		0		33 PC
Subtotal	~1991/~1995	202,567	≥256,212(≥281)	6.0	

Appendix 1—Continued

Region	Years of two most recent surveys	Estimated number of nesting pairs (no. colonies)[1]		MPAC	Source[3]
	Year 1[2]/Year 2	Year 1[2]	Year 2		
Southeast					
Alabama	1992/1996	0	0		34 PC
Delaware	1992/1996	0	0		2 UD
Florida	1986–89/1986–89	12,000C	12,000C		5
Georgia	1991/1996	3D	?[4]		35 PC
Louisiana	1990/1996	100D	<200D	<12.2	36 UD
Maryland	1992/1995	300C	491(2)A	17.8	37 UD
Mississippi	1992/1993	0	0		38 PC
North Carolina	1992/1995	20C	0		2 UD
South Carolina	1990/1994	115A	515(8)A	45.5	39
Texas	1990/1996	6A	?[4]		40 PC
Virginia	1992/1993	50A	398(5)A	696.0	41 UD
Subtotal	~1991/~1994	12,594	>13,604 (>15)	2.6	
West Coast and Alaska					
Alaska	1975–92/1996	2,924C	2,935(120)C	0.02 to 0.09	42 UD
Arizona	1992/1996	750C	(<15-20)C		43 PC
British Columbia	1987–89/1988	1,753B	2,032(15)C		44
California	1989–91/1993–95	5,592A,C	2,394(17)C		45, 46 PC
Idaho	1984/1993	850B	~1,288(11)C	4.7	47
Nevada	1992/1994	1,500C	≥80(≥3)C	–76.9	48
Oregon	1988–92/1992	7,167A,C	6,987(24)A		45
Utah	1987–92/1987–96	1,200B	482(15)D		49 UD
Washington	1992/1995	2,018A,C	886(21)C	–24.0	50 UD
Subtotal	~1989/~1993	23,754	≥17,084(243)	–7.9	
Total	**~1990/~1994**	**336,490**	**>372,410(>852)**	**2.6**	

[1] Classifications for the various population estimates: A = recent complete count; B = extrapolated older count or other informed estimate; C = estimate, often based on knowing of most colonies but few counts of individuals; D = guess: only old, indirect, or scattered recent knowledge available.

[2] From Hatch (1995).

[3] UD = unpublished data; PC = personal communication; 1 = J. Victoria, Connecticut Dept. of Environmental Protection; 2 = B. Hoover, U.S. Geological Survey; 3 = Erskine (1992); 4 = J. Kantor, New Hampshire Fish and Game Department; 5 = Hatch (1995); 6 = L. Sommers, New York Dept. of Environmental Conservation; 7 = G. Milton, Canadian Wildlife Service; 8 = A. McLennan, Prince Edward Island Environmental Resources; 9 = M. LeBage, Quebec Ministry of the Environment; 10 = Cairns et al. (1989); 11 = S. Brechtel, Alberta Dept. of Environmental Protection; 12 = Andrews and Ryder (1992); 13 = V. Kleen, Illinois Dept. of Natural Resources; 14 = J. Castrale, Indiana Dept. of Natural Resources; 15 = L. Hemesath, Iowa Dept. of Natural Resources; 16 = B. Busby, Kansas Biological Survey; 17 = Palmer–Ball and Wethington (1994); 18 = coauthor Francesca Cuthbert; 19 = M. Miller, Minnesota Dept. of Natural Resources; 20 = J. Wilson, Missouri Dept. of Conservation; 21 = K. Jurist, Montana Natural Heritage Foundation; 22 = S. Williams, New Mexico Dept. of Game and Fish; 23 = G. Burkee, Minot State University; 24 = B. Bromley, Northwest Territories Dept. of Renewable Resources; 25 = R. Shephard, U.S. Fish and Wildlife Service; 26 = coauthor D. V. Weseloh; 27 = D. Brauning, Pennsylvania Game Commission; 28 = Peterson (1995); 29 = G. Lee, Commander, Holston Army Ammunitions Plant; 30 = M. Ferguson, Vermont Dept. of Fish and Wildlife; 31 = S. Butterworth, Virginia Dept. of Natural Resources; 32 = A. Cerovski, Wyoming Game and Fish Department; 33 = D. H. Mossop, Yukon Territories Dept. of Renewable Resources; 34 = R. Clay, Alabama Dept. of Conservation and Natural Resources; 35 = T. Schneider, Georgia Dept. of Natural Resources; 36 = W. Vermillion, Louisiana Dept. of Wildlife and Fish; 37 = G. Therres, Maryland Dept. of Natural Resources; 38 = P. Mastrangelo, U.S. Dept. of Agriculture, Wildlife Services; 39 = South Carolina Dept. of Natural Resources (1996); 40 = W. Roach, U.S. Fish and Wildlife Service; 41 = G. Costanzo, Virginia Dept. of Game and Inland Fisheries; 42 = S. Stephensen, U.S. Fish and Wildlife Service; 43 = T. Corman, Arizona Game and Fish Department; 44 = Campbell et al. (1990); 45 = Carter et al. (1996); 46 = S. Tappen, Audubon Canyon Ranch; 47 = Trost and Gerstell (1994); 48 = Herron (1994); 49 = F. Howe, Utah Division of Wildlife Resources; 50 = U. Wilson, U.S. Fish and Wildlife Service.

[4] Species known to breed; recent data unavailable.

[5] Number represents only one colony; more nesting suspected elsewhere.

[6] Number represents counts from only one county in State.